Debuncher Momentum Cooling Systems Signal to Noise Measurements

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The Debuncher Momentum cooling systems were carefully measured for signal to noise. It was observed that cooling performance was not optimum. Closer inspection shows that the installed front-end bandpass filters are wider than the pickup response. (The original filters were specified to be wider so that none of the available bandwidth would be clipped.) The end result is excess noise is amplified and passed onto the kickers unimpeded, hence, reducing the achievable system gain. From this data, new filters should be designed to improve performance. New system bandwidths are specified on the data figures.

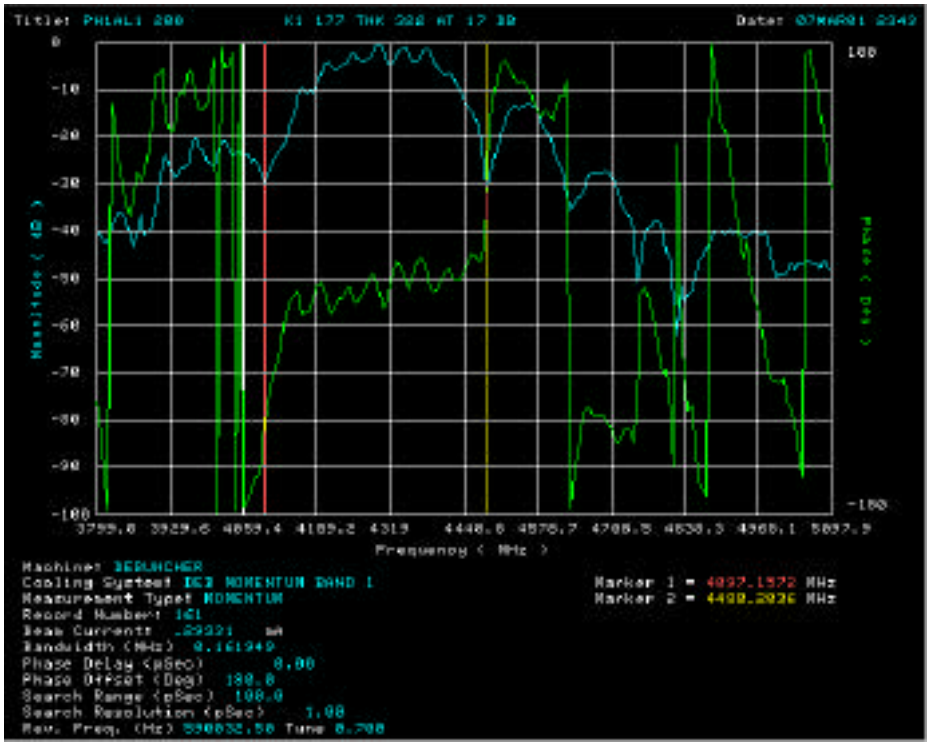
Also included are the transfer function measurements that clearly show adjacent band response. In band 4 upper, the adjacent lobes are strong and out of phase. This is also degrading the system performance. The correlation between spectrum analyzer signal to noise and network analyzer system transfer functions is very strong. The table below has a calculation of expected improvement of front noise reduction by means of building new front-end bandpass filters. The calculation is based on a flat input noise spectrum and is a linear estimation of improvement. The listed 3dB bandwidths of the original filters are from measured data. The expected bandwidth is taken from the linear spectrum analyzer plots and is closer to a 10 dB bandwidth making the percentage improvement conservative.

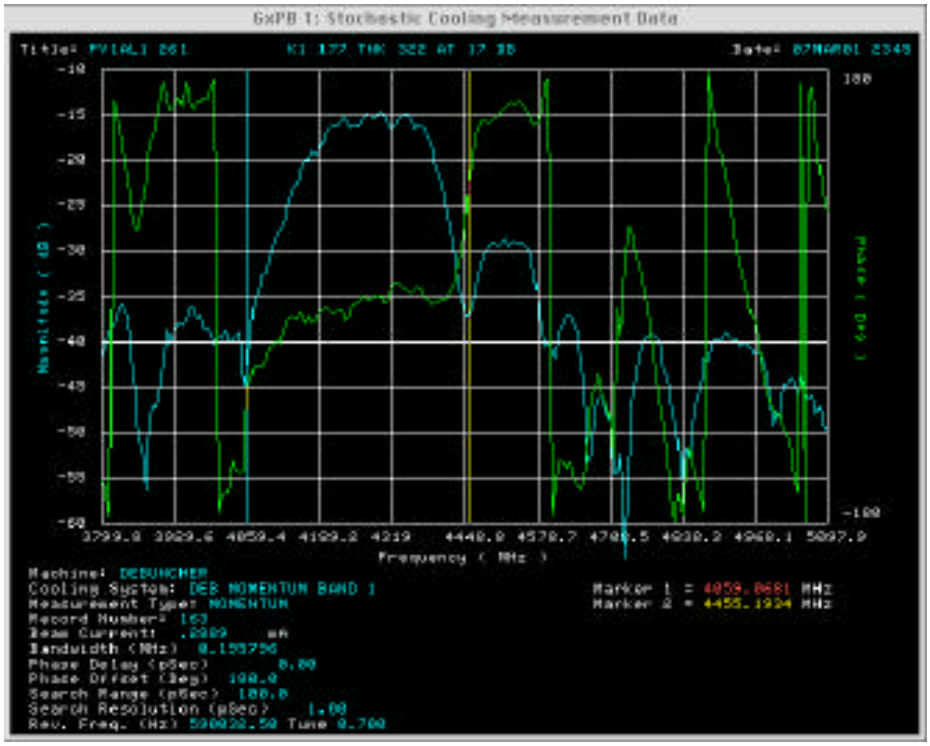
The signal to noise measurements are taken with circulating pbars in the Debuncher. One cooling system was measured at a time with all others off. Beam currents are below ten microamperes.

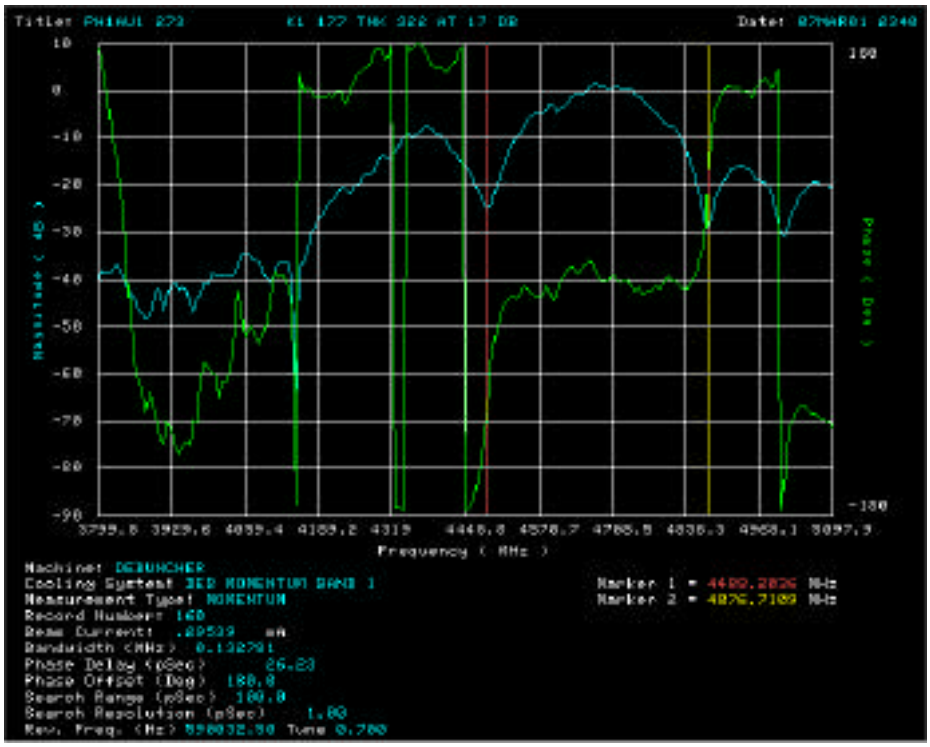
Debuncher Momentum System Signal to Noise Performance

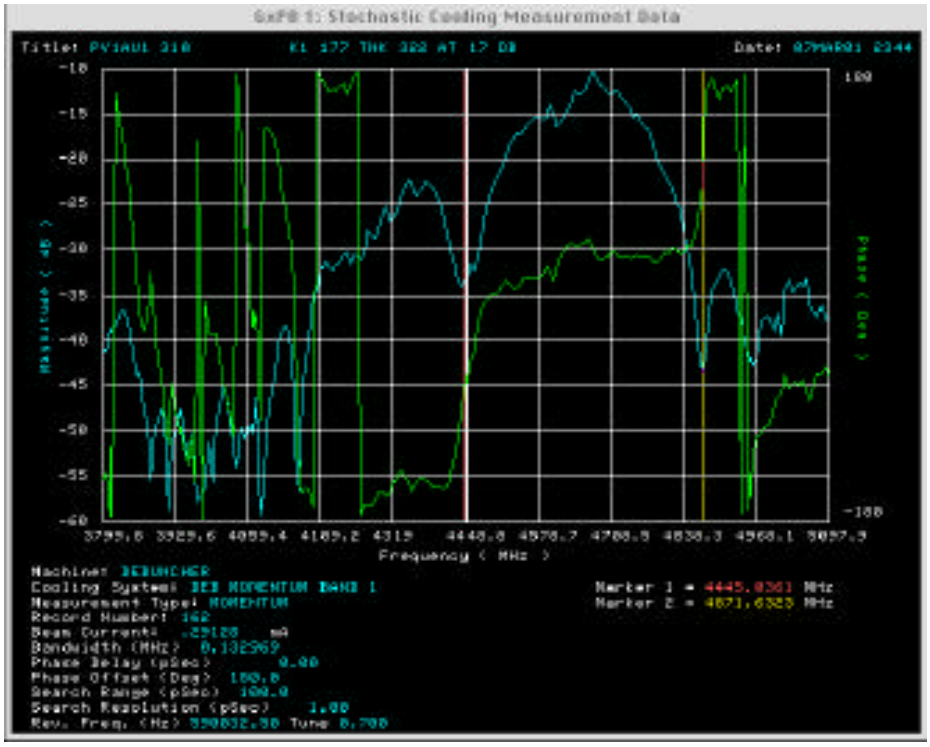
Band	Current 3 dB Bandwidth MHz	Expected Bandwidth New filters	Percent improvement
1	1700	1000	59%
2	1800	1000	56%
3	1900	1200	63%
4	1900	1100	58%

This performance is based on the assumption of a flat noise input spectrum.

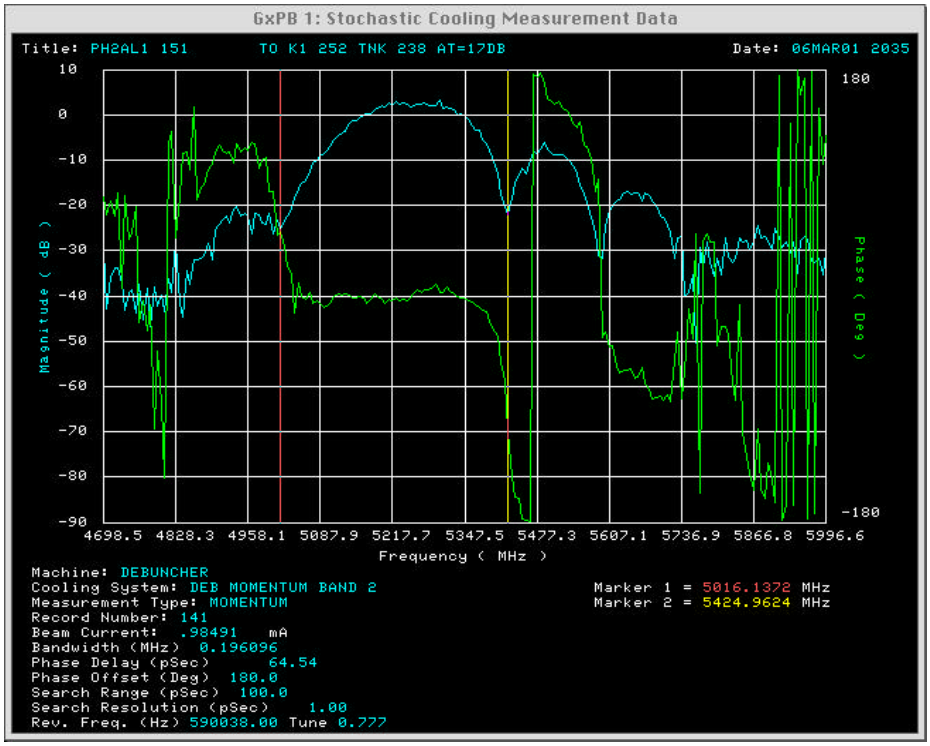

Title: PHIALI 200
K1 177 THK 322 AT 17 30
Date: 07MAR01 2342
Magnitude (dB)
Phase (Deg)
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DE3 MOMENTUM BAND 1
Measurement Type: MOMENTUM
Record Number: 161
Beam Current: .29921 mA
Bandwidth (MHz) 0.161949
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590032.50 Tune 0.700
Marker 1 = 4097.1572 MHz
Marker 2 = 4400.2026 MHz

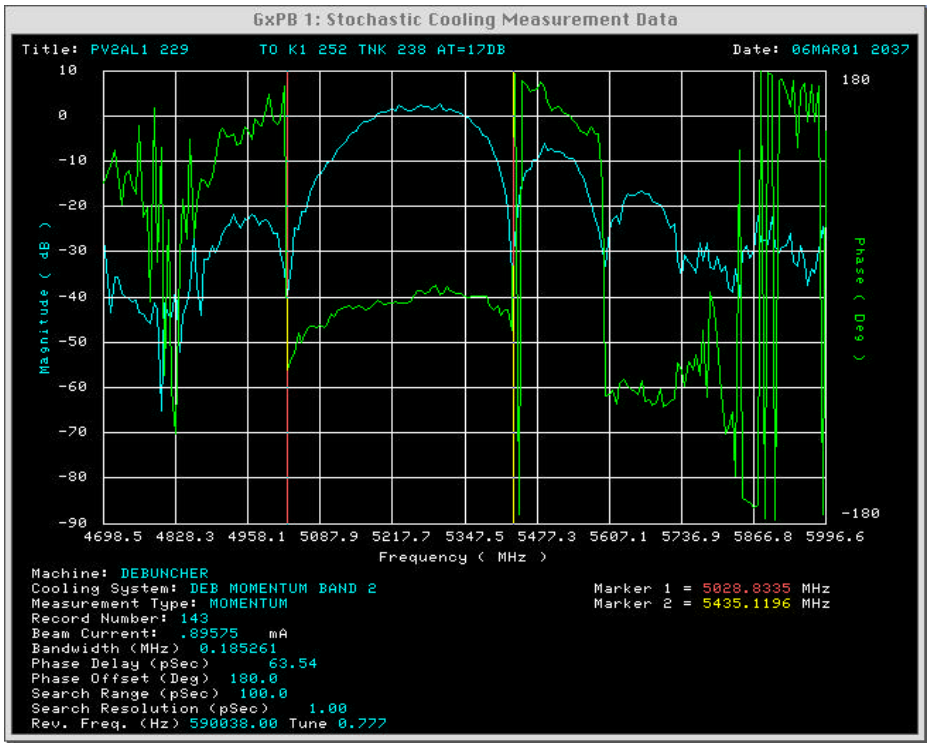

GxPB 1: Stochastic Cooling Measurement Data
Title: PHIALI 261
K1 177 THK 322 AT 17 30
Date: 07MAR01 2345
Magnitude (dB)
Phase (Deg)
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DE3 MOMENTUM BAND 1
Measurement Type: MOMENTUM
Record Number: 163
Beam Current: .2889 mA
Bandwidth (MHz) 0.155756
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590032.50 Tune 0.700
Marker 1 = 4059.8681 MHz
Marker 2 = 4455.1934 MHz

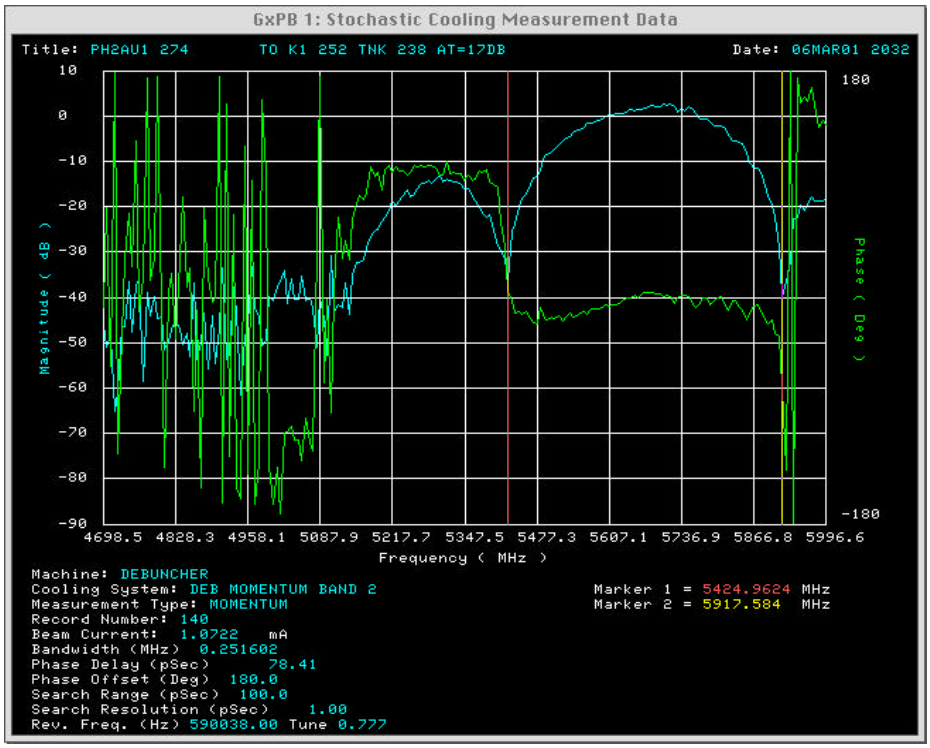

Title: PHIAUI 273 E1 177 THK 322 AT 17 DB Date: 07MAR01 2240
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
100
-100
Magnitude (dB)
Phase (Deg)
3795.8 3929.6 4063.4 4197.2 4331 4464.8 4598.7 4732.5 4866.3 5000.1 5097.9
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: 3E8 MOMENTUM BAND 1
Measurement Type: MOMENTUM
Record Number: 160
Beam Current: .29539 mA
Bandwidth (MHz) 0.132791
Phase Delay (pSec) 26.23
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 550032.50 Tune 0.700
Marker 1 = 4492.2826 MHz
Marker 2 = 4876.7188 MHz

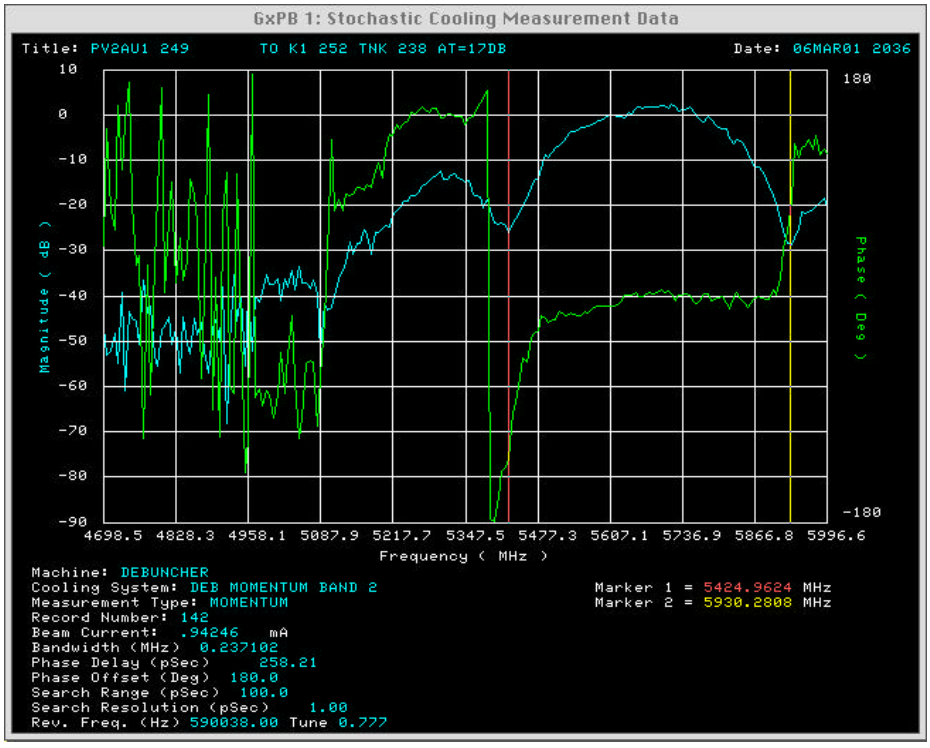

GxFB 1: Stochastic Cooling Measurement Data
Title: PVIAUI 310 E1 177 THK 322 AT 17 DB Date: 07MAR01 2344
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
100
-100
Magnitude (dB)
Phase (Deg)
3795.8 3929.6 4063.4 4197.2 4331 4464.8 4598.7 4732.5 4866.3 5000.1 5097.9
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: 3E8 MOMENTUM BAND 1
Measurement Type: MOMENTUM
Record Number: 162
Beam Current: .29128 mA
Bandwidth (MHz) 0.1325969
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 550032.50 Tune 0.700
Marker 1 = 4445.0361 MHz
Marker 2 = 4871.6328 MHz

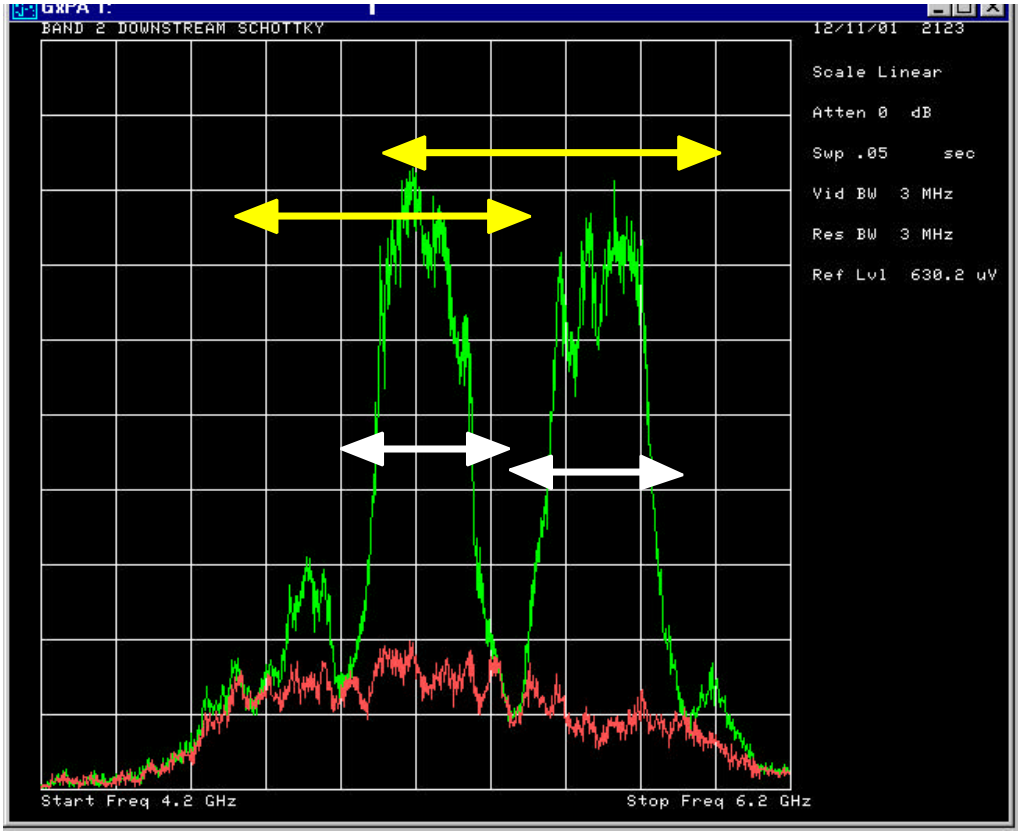
Debuncher Band 1 Momentum Signal to noise.
Yellow Arrows top indicate current filter bandwidths.
Low band 3.8-4.6 Ghz; high band 4.2-5.1 GHz
White Arrows bottom indicate desired filter bandwidths
Low band 4.0-4.5 GHz high band 4.5-5.0 GHz


GxPB 1: Stochastic Cooling Measurement Data
Title: PH2AL1 151
TO K1 252 TNK 238 AT=17DB
Date: 06MAR01 2035
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
180
-180
Magnitude (dB)
Phase (Deg)
4698.5 4828.3 4958.1 5087.9 5217.7 5347.5 5477.3 5607.1 5736.9 5866.8 5996.6
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 2
Measurement Type: MOMENTUM
Record Number: 141
Beam Current: .98491 mA
Bandwidth (MHz) 0.196096
Phase Delay (pSec) 64.54
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590038.00 Tune 0.777
Marker 1 = 5016.1372 MHz
Marker 2 = 5424.9624 MHz

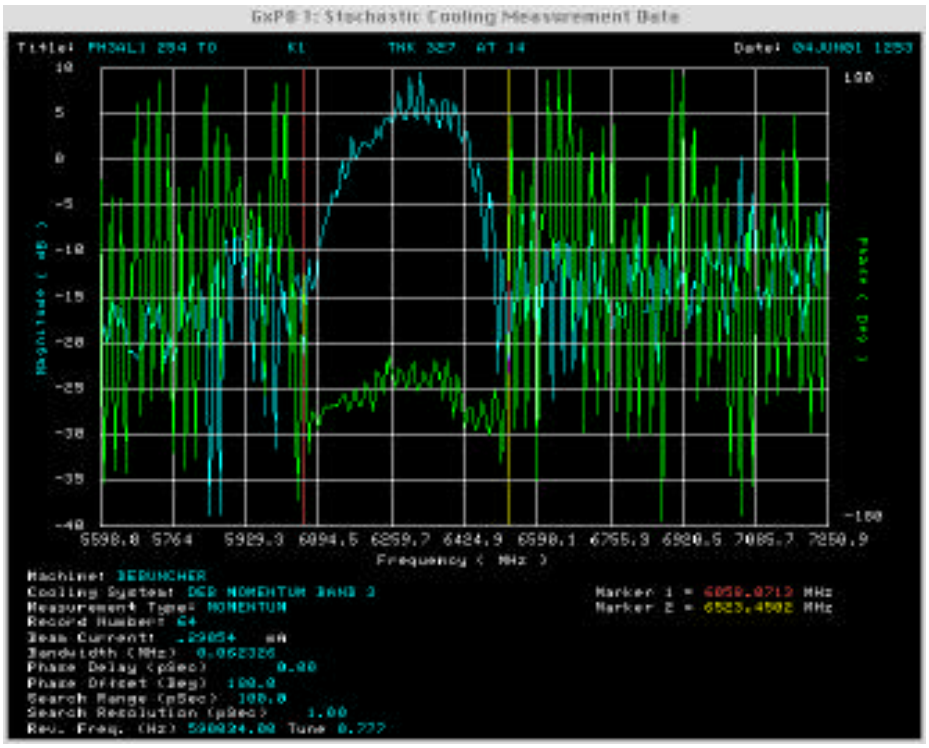

GxPB 1: Stochastic Cooling Measurement Data
Title: PV2AL1 229
TO K1 252 TNK 238 AT=17DB
Date: 06MAR01 2037
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
180
-180
Magnitude (dB)
Phase (Deg)
4698.5 4828.3 4958.1 5087.9 5217.7 5347.5 5477.3 5607.1 5736.9 5866.8 5996.6
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 2
Measurement Type: MOMENTUM
Record Number: 143
Beam Current: .89575 mA
Bandwidth (MHz) 0.185261
Phase Delay (pSec) 63.54
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590038.00 Tune 0.777
Marker 1 = 5028.8335 MHz
Marker 2 = 5435.1196 MHz

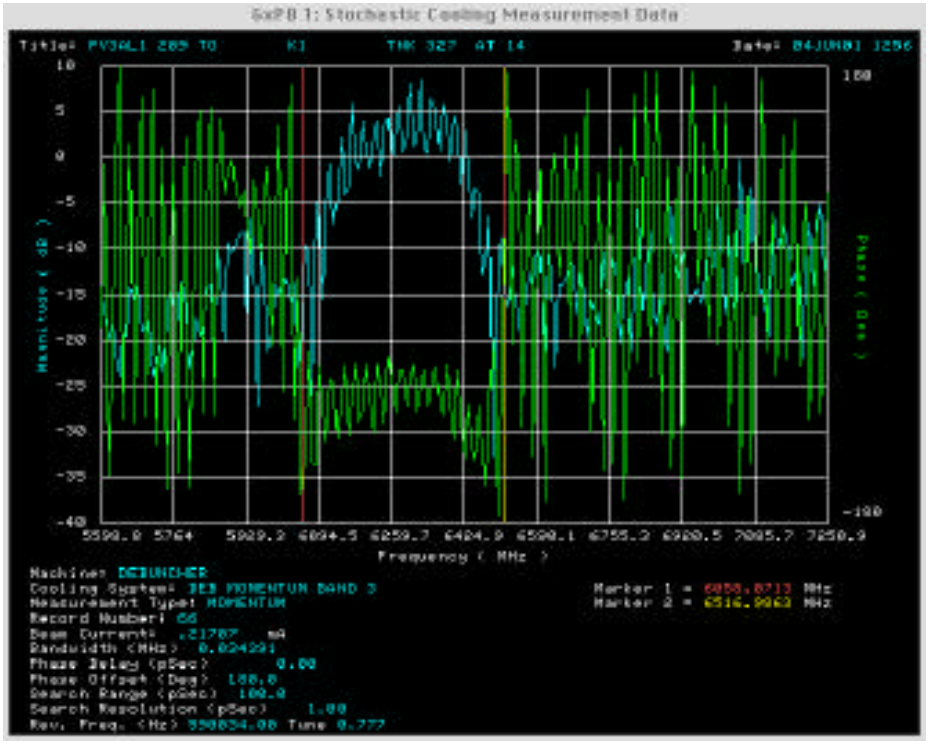

GxPB 1: Stochastic Cooling Measurement Data
Title: PH2AU1 274
TO K1 252 TNK 238 AT=17DB
Date: 06MAR01 2032
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Magnitude (dB)
180
-180
Phase (Deg)
4698.5 4828.3 4958.1 5087.9 5217.7 5347.5 5477.3 5607.1 5736.9 5866.8 5996.6
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 2
Measurement Type: MOMENTUM
Record Number: 140
Beam Current: 1.0722 mA
Bandwidth (MHz) 0.251602
Phase Delay (pSec) 78.41
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590038.00 Tune 0.777
Marker 1 = 5424.9624 MHz
Marker 2 = 5917.584 MHz

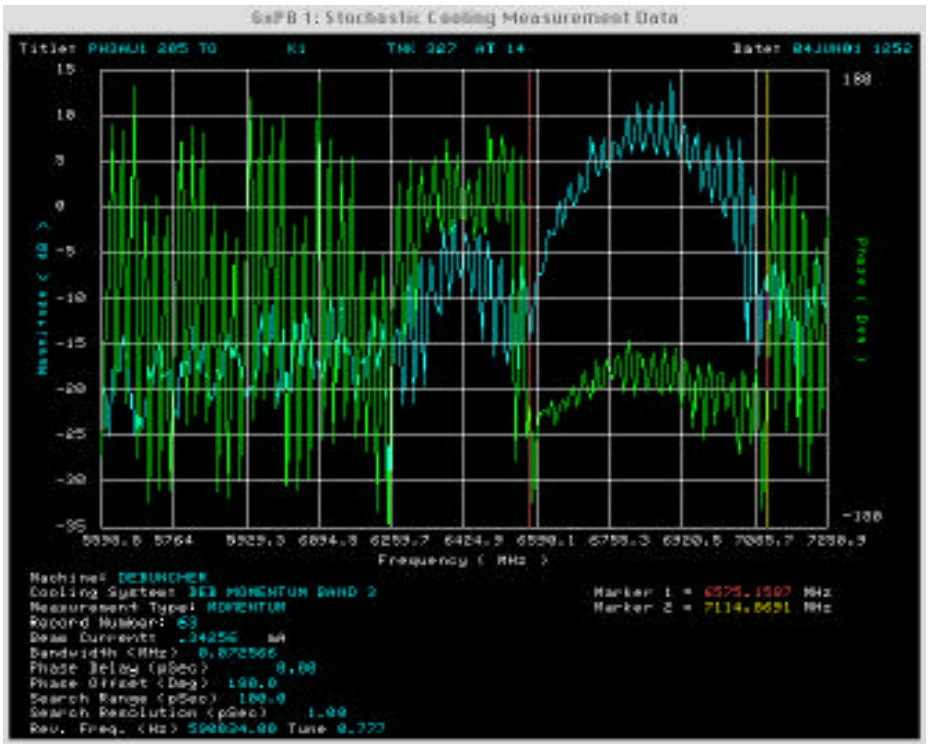

GxPB 1: Stochastic Cooling Measurement Data
Title: PV2AU1 249
TO K1 252 TNK 238 AT=17DB
Date: 06MAR01 2036
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Magnitude (dB)
180
-180
Phase (Deg)
4698.5 4828.3 4958.1 5087.9 5217.7 5347.5 5477.3 5607.1 5736.9 5866.8 5996.6
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 2
Measurement Type: MOMENTUM
Record Number: 142
Beam Current: .94246 mA
Bandwidth (MHz) 0.237102
Phase Delay (pSec) 258.21
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590038.00 Tune 0.777
Marker 1 = 5424.9624 MHz
Marker 2 = 5930.2808 MHz

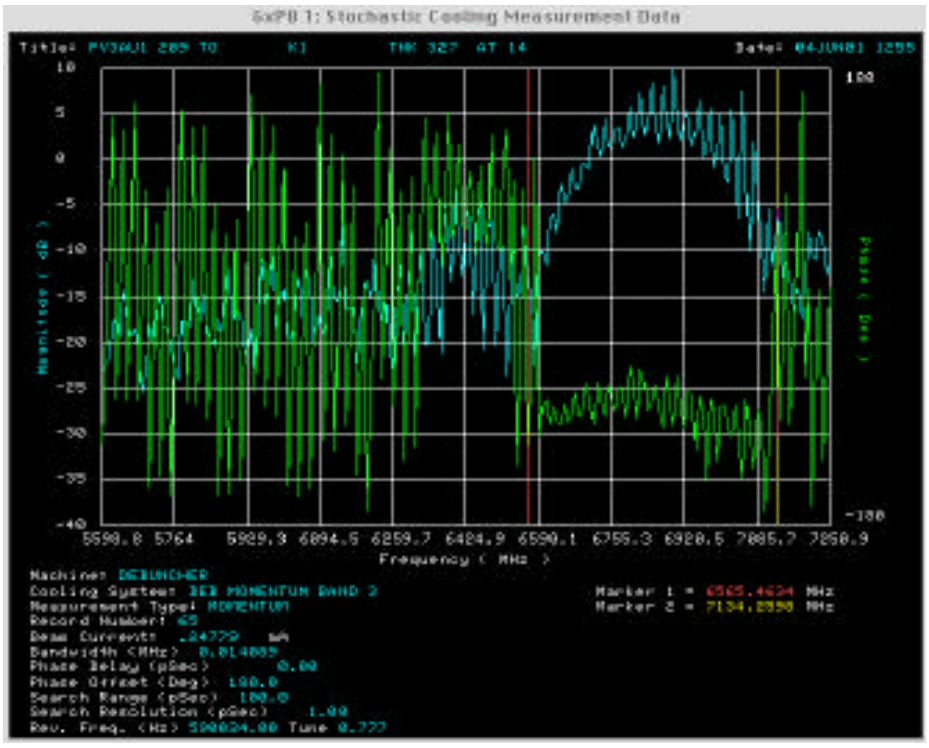


Debuncher Band 2 Momentum Signal to noise
Yellow arrows top indicate current filter bandwidths
Low band 4.7-5.6 GHz; high band 5.1-6.0 GHz
White arrows bottom indicate desired filter bandwidths
Low band 5.0-5.45 GHz; high band 5.45-6.0 GHz

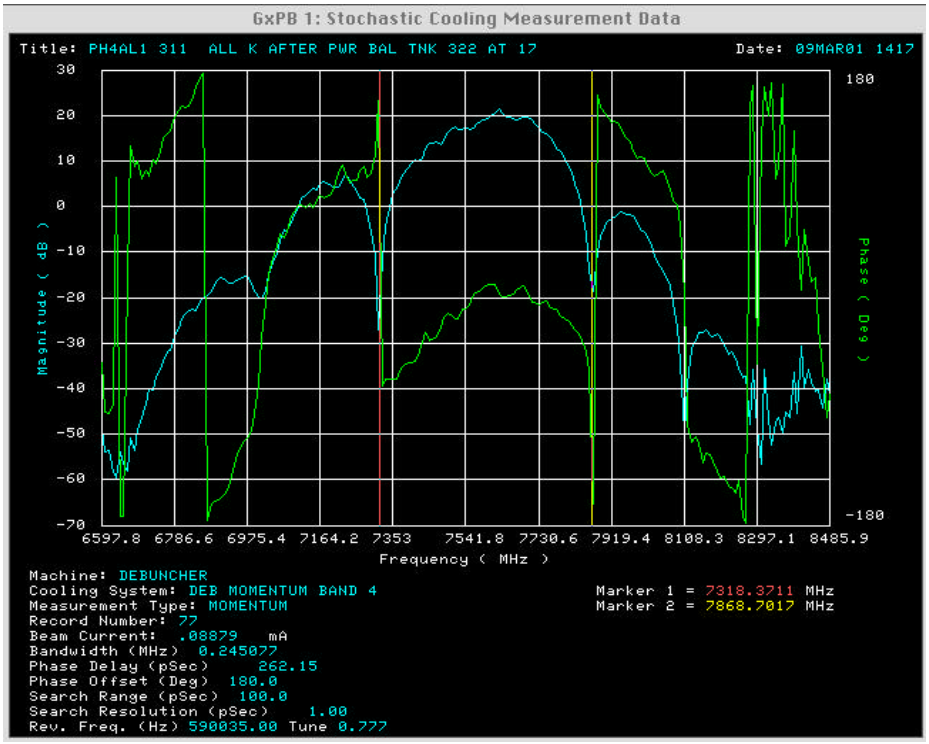

6xP8 1: Stochastic Cooling Measurement Data
Title: PW3AL1 284 TO K1 TNK 327 AT 14
Date: 04JUN01 1253
Magnitude (dB)
Phase (Deg)
5598.8 5764 5929.3 6094.5 6259.7 6424.9 6590.1 6755.3 6920.5 7085.7 7250.9
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 3
Measurement Type: MOMENTUM
Record Number: 64
Beam Current: .29854 mA
Bandwidth (MHz) 0.062326
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590834.00 Tune 0.777
Marker 1 = 6059.0713 MHz
Marker 2 = 6583.4502 MHz

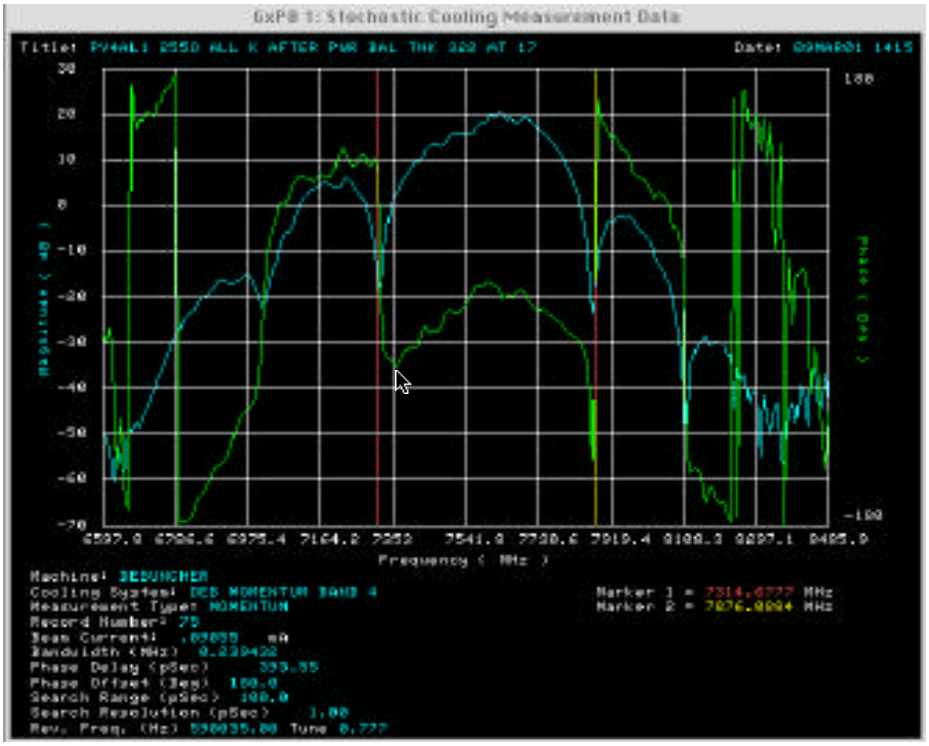

6xP8 1: Stochastic Cooling Measurement Data
Title: PW3AL1 285 TO K1 TNK 327 AT 14
Date: 04JUN01 1256
Magnitude (dB)
Phase (Deg)
5598.8 5764 5929.3 6094.5 6259.7 6424.9 6590.1 6755.3 6920.5 7085.7 7250.9
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 3
Measurement Type: MOMENTUM
Record Number: 66
Beam Current: .21787 mA
Bandwidth (MHz) 0.024291
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590834.00 Tune 0.777
Marker 1 = 6059.0713 MHz
Marker 2 = 6516.9963 MHz

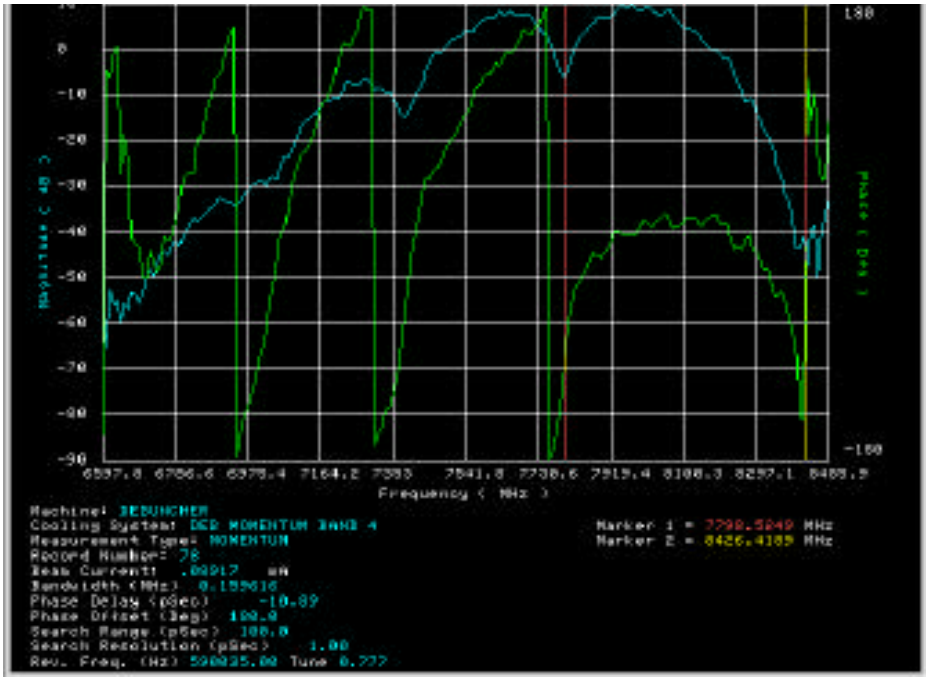

SxPB 1: Stochastic Cooling Measurement Data
Title: PW3AUI 205 TO K1 TNK 327 AT 14
Date: 04JUN01 1252
Magnitude (dB)
Phase (Deg)
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: 3E3 MOMENTUM BAND 2
Measurement Type: MOMENTUM
Record Number: 63
Beam Current: .24256 mA
Bandwidth (MHz) 0.872566
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590024.00 Tune 0.777
Marker 1 = 6575.1597 MHz
Marker 2 = 7134.8691 MHz

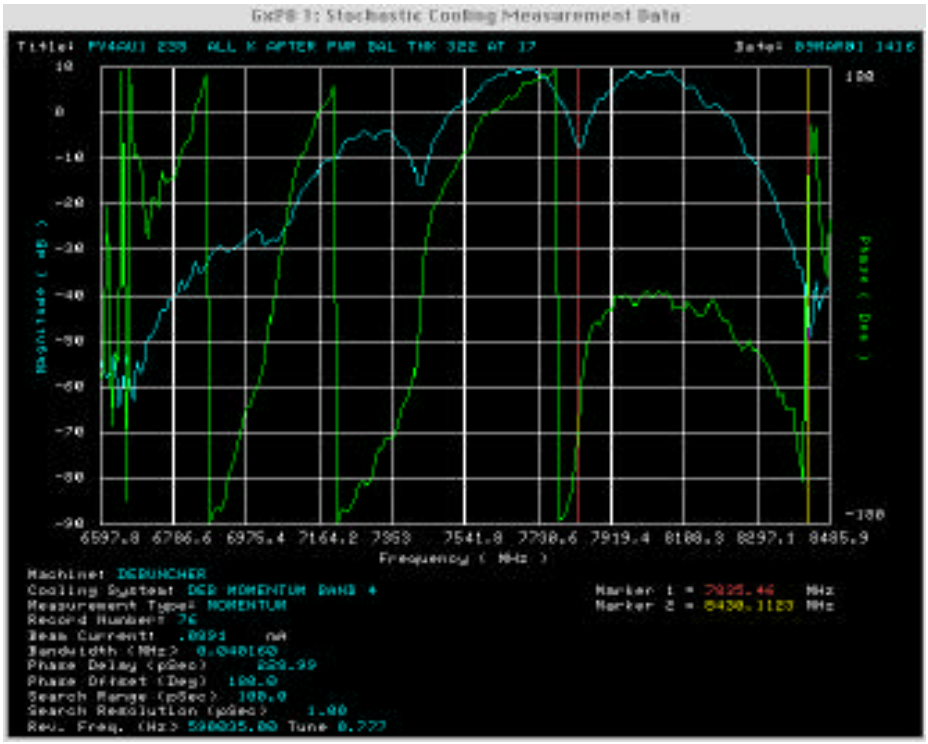

SxPB 1: Stochastic Cooling Measurement Data
Title: PW3AUI 205 TO K1 TNK 327 AT 14
Date: 04JUN01 1255
Magnitude (dB)
Phase (Deg)
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: 3E3 MOMENTUM BAND 2
Measurement Type: MOMENTUM
Record Number: 65
Beam Current: .24779 mA
Bandwidth (MHz) 0.814865
Phase Delay (pSec) 0.00
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590024.00 Tune 0.777
Marker 1 = 6565.4624 MHz
Marker 2 = 7134.8398 MHz

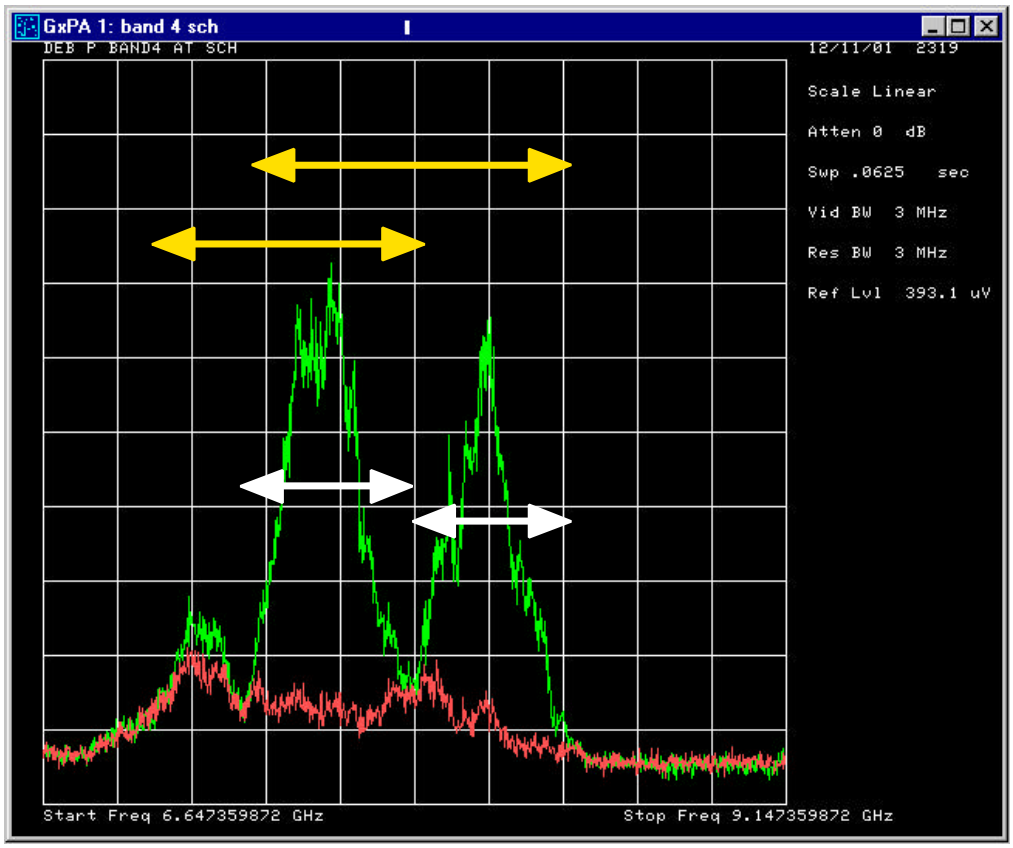
Debuncher Band 3 Momentum Signal to noise.
Yellow Arrows top indicate current filter bandwidths.
Low band 5.9-6.5 Ghz; high band 6.4-7.7 GHz
White Arrows bottom indicate desired filter bandwidths
Low band 6.0-6.6 GHz high band 6.6-7.2 GHz


GxPB 1: Stochastic Cooling Measurement Data
Title: PH4AL1 311 ALL K AFTER PWR BAL TNK 322 AT 17
Date: 09MAR01 1417
Magnitude (dB)
Phase (Deg)
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 4
Measurement Type: MOMENTUM
Record Number: 77
Beam Current: .08879 mA
Bandwidth (MHz) 0.245077
Phase Delay (pSec) 262.15
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590035.00 Tune 0.777
Marker 1 = 7318.3711 MHz
Marker 2 = 7868.7017 MHz


GxPB 1: Stochastic Cooling Measurement Data
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DEB MOMENTUM BAND 4
Measurement Type: MOMENTUM
Record Number: 75
Bandwidth (MHz) 0.239402
Phase Delay (pSec) 393.55
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590035.00 Tune 0.777


Magnitude (dB)
Phase (Deg)
100
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
6597.8 6786.6 6975.4 7164.2 7353 7541.8 7730.6 7919.4 8108.3 8297.1 8485.9
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DCB MOMENTUM BAND 4
Measurement Type: MOMENTUM
Record Number: 28
Beam Current: .0091 mA
Bandwidth (MHz) 0.139616
Phase Delay (pSec) -10.89
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590035.00 Tune 0.727
Marker 1 = 7290.5049 MHz
Marker 2 = 8426.4189 MHz


GxPB 1: Stochastic Cooling Measurement Data
Title: PV4AU1 235 ALL K AFTER PWR BAL THK SEE AT 17
Date: 05MAR01 1416
Magnitude (dB)
Phase (Deg)
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
100
-100
6597.8 6786.6 6975.4 7164.2 7353 7541.8 7730.6 7919.4 8108.3 8297.1 8485.9
Frequency (MHz)
Machine: DEBUNCHER
Cooling System: DCB MOMENTUM BAND 4
Measurement Type: MOMENTUM
Record Number: 76
Beam Current: .0091 mA
Bandwidth (MHz) 0.040160
Phase Delay (pSec) 220.99
Phase Offset (Deg) 180.0
Search Range (pSec) 100.0
Search Resolution (pSec) 1.00
Rev. Freq. (Hz) 590035.00 Tune 0.727
Marker 1 = 7925.46 MHz
Marker 2 = 8430.1123 MHz



Debuncher Band 4 Momentum Signal to noise.
Yellow Arrows top indicate current filter bandwidths.
Low band 7.0-7.9 Ghz; high band 7.4-8.4 GHz
White Arrows bottom indicate desired filter bandwidths
Low band 7.3-7.9 GHz high band 7.9-8.4 GHz